Asian Journal of Chemistry Vol. 21, No. 10 (2009), S095-098

Dielectric Studies of Carbon Nanotube Doped Ferroelectric Liquid Crystal Films

P. MALIK*, A. CHAUDHARY† and K. K. RAINA††
**Department of Physics, Dr. B. R. Ambedkar National Institute of Technology, Jalandhar, 144 011, Punjab, India*
Tel: + 919888382021, Email- pmalik100@yahoo.com

A small amount (0.05% & 0.1% wt. /wt.) of multiwall carbon nanotube doped ferroelectric liquid crystal sample cell were prepared and studied. The dielectric measurements have been investigated as a function of temperature and frequency in the frequency range of 50Hz to 1MHz. A decrease in dielectric permittivity (~40%) in 0.1% CNT doped FLC sample was found over 0.05% doped sample. The relaxation frequency of goldstone mode was found ~ 119-161Hz and 116-182Hz respectively for 0.1% and 0.05% CNT doped cells.

Key Words: Ferroelectric liquid crystal, Goldstone mode, Multiwall Carbon nanotube

INTRODUCTION

During the last five years, the combination of carbon nanotube (CNT) and liquid crystal (LC) materials shows considerable interest in the scientific community due to unique physical properties of CNT in liquid crystal[1]. CNT influence the existing properties of liquid crystal host and it has been suggested that with the doping of CNT can enhance the properties of LC for displays applications [2-5]. In this work, an attempt has been made to study the temperature and frequency dependence on dielectric parameters in CNT –ferroelectric liquid crystal (FLC) films.

EXPERIMENTAL

Room temperature FLC trade name (ZLI-3654)[6] procured from E. Merck and multiwall carbon nanotube (MWCNT) from Sigma Aldrich[7] were used as basic materials. The phase sequence of the FLC materials is given by $K \xleftarrow{<-30\,^{\circ}C} SmC^{*} \xleftarrow{62\,^{\circ}C} SmA \xleftarrow{76\,^{\circ}C} Ch \xleftarrow{86\,^{\circ}C} I$. Small amount of MWCNT (0.05% & 0.1% wt./wt.) was mixed into FLC mixture at room temperature. For complete homogeneous mixture, a few drops of chloroform were added and finally ultrasonification was done at a frequency of 42 KHz at 60° C. The homogeneous mixture was then filled between two cleaned thicknesses of 10µm. These cells were sealed using araldite. The electrodes were connected at the ITO surface of the cell using indium. The sample cells were then placed in a hot stage attached with temperature controller (LINKAM-THMS-600). Dielectric studies were taken with the help of LCR (FLUKE- PM 6306) in the range of 50 Hz to 1MHz.

††Coauthor address-Materials Research Laboratory, Thapar University, Patiala, India; Email-rainatietp@yahoo.com

RESULTS AND DISCUSSION

Temperature dependence of dielectric permittivity

The temperature dependence of dielectric permittivity (ε') at varying frequencies in both samples are shown in fig. 1. Fig. 1(a) shows that dielectric permittivity (ε') increased up to 62°C in SmC* and there after a decrease in ε' is noticed up to N* phase. The value of dielectric permittivity is more predominant at low frequencies (500Hz, 1 KHz). However at higher frequencies, no significant variation in dielectric permittivity was observed. It may be due to that at higher frequencies, LC dipoles have not sufficient time to align themselves with the direction of field. At high temperature, thermal agitation became more dominant over intermolecular interaction which produces randomization of dipoles. This randomization results a decrease in dielectric permittivity at higher temperature. The temperature dependence of imaginary part of dielectric permittivity (ε") at different frequency is also shown in fig. 2. It can be seen from fig. 1 and fig. 2 that with addition of 0.1% CNT in FLC mixture, permittivity decreases ~ 40% over 0.05% doped CNT in FLC mixture.

Frequency dependence of dielectric permittivity

The frequency dependence on dielectric permittivity (ε') at different temperatures are shown in fig. 3. It can be seen from fig. 3(a) that for 0.05% doped FLC sample cell, ε' increases from 31^0C to 62^0C to a value from 120 to 900 and after that permittivity continuously decreases to a very low value 20-30**.** It can be seen from fig. 3(b) that permittivity increases from room temperature 31^0C to 75^0C i.e. almost up to SmA phase to a value from ~15 to ~175 and after that permittivity decreases. Fig. 4 shows the frequency dependence of ε″ at different temperatures of both samples.

Fig. 4(a) and Fig 4(b) show that relaxation peak appears in the range of 150 to 170 Hz in SmC* phase and slightly shifts to ~200Hz with the increase of the temperature. The observation of only one peak in both samples suggests only one mode in the frequency of 150-200Hz. The appearance of only one peak suggests the presence of goldstone mode.

Dielectric relaxation

The relaxation frequency (f_r) can be evaluated using an expression[8]

$$(V/U) = (\omega\tau)^{1-\alpha} \quad (1)$$

Where

$$V = [\{\varepsilon(0) - \varepsilon'(\omega)\}^2 + \{\varepsilon''(\omega)\}^2]^{1/2} \quad (2)$$

$$U = [\{\varepsilon'(\omega) - \varepsilon(\infty)\}^2 + \{\varepsilon''(\omega)\}^2]^{1/2} \quad (3)$$

The used symbols in equation 1-3 are defined earlier. The calculated values of f_r for both samples are shown in table 1.

Table 1 Temperature dependence on relaxation frequency

Temperature (°C)	f_r(Hz)	
	0.05% doped cell	0.1% doped cell
35	119.00	116
40	118.02	142
45	111.60	168
50	126.28	156
60	131.94	170
62	146.35	177
67	161.94	182

It is observed that in SmC* phase f_r is almost constant however a little change in f_r was seen near to SmC* to SmA transition.

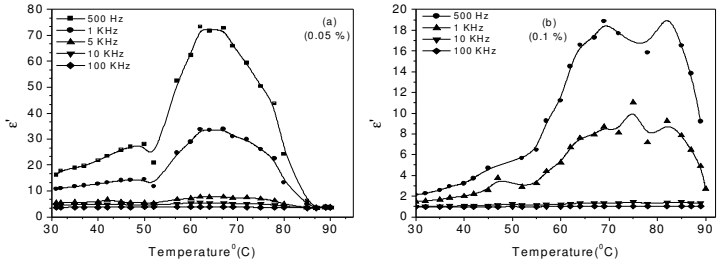

Fig. 1 Temperature dependence on dielectric permittivity (ε') at varying frequencies for (a) 0.05% (b) 0.1% CNT doped FLC sample

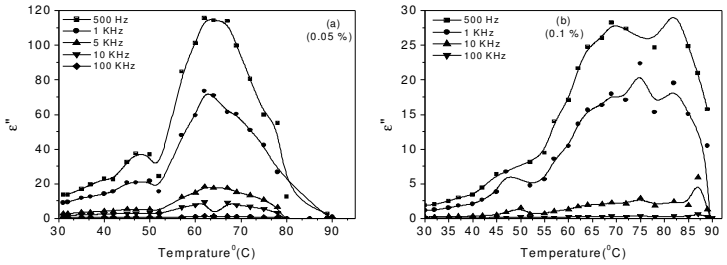

Fig. 2 Temperature dependence on dielectric permittivity (ε") at different frequencies for (a) 0.05% (b) 0.1% CNT doped FLC sample

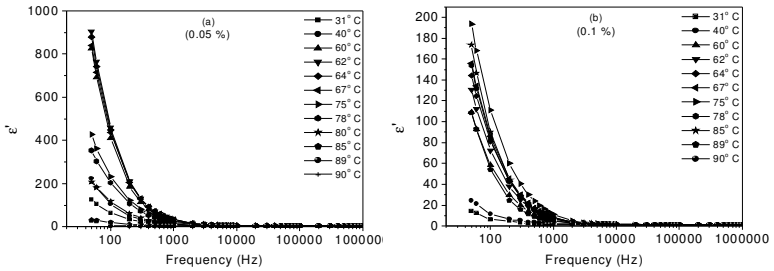

Fig. 3 Frequency dependence of dielectric permittivity (ε') at different temperatures (a) 0.05% (b) 0.1%

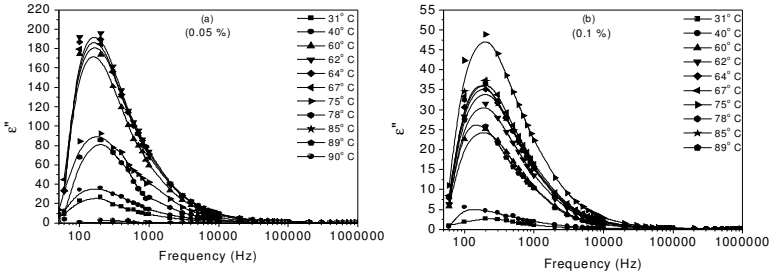

Fig. 4 Frequency dependence of dielectric permittivity (ε") at different temperatures (a) 0.05% (b) 0.1%

Conclusions

Dielectric permittivity increases in SmC* phase and then decreases up to N* phase in both samples and nearly 40% decreases in permittivity is noticed for 0.1% CNT doped FLC sample cell than 0.05% sample. Only single relaxation peak at ~ 200Hz is seen in both sample suggest goldstone mode.

ACKNOWLEDGEMENTS

Authors thank to Director, NIT Jalandhar and Thapar University Patiala for providing the experimental facility.

REFERENCES

1. H. Qi and T. Hegmann, *J. of Mater. Chem.* **18**, 3288 (2008).
2. K. A. Dean, A new ear: nanotubes displays, *Nat. Photonics,* **1**, 273 (2007).
3. A. Schindler, J. Brill, N. Fruehauf, *Physica E*, **37**, 119 (2007).
4. R. King, F. Roussel, *Appl. Phys. A,* **86**, 159 (2007).
5. I. Dierking, G Scalia and P Morales, *J. Appl. Phys.,* **97**, 044309 (2005).
6. E. Merck, Germany
7. Sigma Aldrich, India.
8. P. Malik. K.K.Raina, A. Bubnov and C. Prakash, *Phase Trans*., **79**, 889 (2006).